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Assessment of material and technological resources for the teaching and learning of programming languages on the first-year computer science degree programme in Lubumbashi

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ABSTRACT

The main objective of this study is to evaluate the material and technological resources deployed for the teaching and learning of programming in the first-year computer science degree programme in Lubumbashi. The methodology is based

on a survey and a literature review involving a sample of 514 students (representing 36.53 per cent of the enrolled population) and 12 lecturers across 10 institutions. Data analysis was carried out using Excel and R software. The results highlight structural shortcomings regarding computer laboratories and access to the internet. In conclusion, the lack of suitable equipment and limited access to the network

prevent students from using Integrated Development Environments (IDEs) with ease. This infrastructural shortfall results in inadequate training, which limits self-directed learning and the competitiveness of future IT professionals.

Keywords: Computer Science Pedagogy, Programming Language, Technological Resources, Lubumbashi, Integrated Development Environment.

1. Introduction

Context and Rationale

Computer science is a discipline with an ‘evolving structure’ (Nsenge, 2020), the teaching of which has become widespread across all faculties due to its vital importance. In Lubumbashi, institutions are facing a growing demand from students, which creates critical logistical challenges in terms of capacity and equipment. As Nsenge (2020) points out, the exponential growth of this discipline in the Democratic Republic of the Congo requires lecturers to possess in-depth expertise in order to avoid ‘sloppily taught courses’ and a lack of practical skills among learners. It is therefore imperative that the available equipment meets the demands of modern programming.

Research Question

The central question of this research concerns the inability of first-year students to use the Integrated Development Environment (IDE) for the programming languages they are learning with ease. Initially ‘very enthusiastic’ about the idea of transforming their environment through code, students quickly face ‘discouragement’ (Mandela, 2023, p. 8) due to the contrast between their aspirations and the reality of the infrastructure. The argument is based on the hypothesis that a learning environment lacking adequate equipment condemns students to a sterile theoretical approach.

Objective

This article specifically aims to highlight the state of the equipment and the actual level of internet access for teachers and students in Lubumbashi in the teaching and learning of programming languages.

Hypothesis

We postulate that the acute shortage of IT equipment, suitable teaching materials and permanent internet access constitutes the major obstacle to the practical mastery of programming languages, isolating learners from global technological standards.

2. Methodology

Research Approach and Data Collection Techniques

The study adopts a mixed-methods approach combining fieldwork and desk research. Data were collected using four complementary techniques:

1. **Documentation:** Analysis of official texts and teaching materials.
2. **Questionnaire:** Administered to students and teachers to quantify usage patterns.
3. **Semi-structured interviews:** To explore pedagogical constraints in greater depth.
4. **Direct observation:** On-site assessment of laboratories and equipment.

Population and Sampling

The target population comprises 1,407 students enrolled on the first-year computer science degree programme in Lubumbashi. The final sample consists of **514 students** (representativeness rate of **36.53 per cent**) and **12 teachers**, spread across **10** universities and higher education **institutions**.

Analytical tools

Statistical processing and data modelling were carried out using **Excel** and **R** software, ensuring the rigour of the descriptive analysis.

3. Results (statistical analysis of resources)

The empirical assessment reveals infrastructure saturation and a reliance on private resources.

3.1. Basic infrastructure and overloading of IT equipment

The learning environment is characterised by a shortage of functional laboratories and equipment that is often obsolete.

a. Existence of a Computer Lab

In order to ascertain whether a computer laboratory exists within an institution, the following question was asked: ‘Do you have a computer laboratory?’. The responses provided by our respondents are presented in the table below:

Table 1: Presence of a computer lab.

Availability of the computer lab	Number of staff	%
No	1	8.33
Yes	11	91.67
Total	12	100.00

Analysis of Table 1 shows that, out of a total of 12 teachers representing 100 per cent, the majority (11, or 91.67 per cent) of teachers confirmed the existence of a computer laboratory within their institutions.

The chi-squared test yielded a value of 8.333 ($p = 0.003$) with one degree of freedom; this leads us to reject the null hypothesis.

b. Number of computers in use and in good working order in the laboratory

In order to determine the number of computers in use and in good working order in a computer laboratory, the following question was asked: ‘How many computers in use and in good working order do you have in your computer laboratory?’. The responses provided by our respondents are presented in the table below:

Table 2: Computers in use and in good working order in a computer lab.

Number of computers	Number of respondents	%
1 to 25 computers	8	72.73
26 to 50 computers	2	18.18
51 to 100 computers	1	9.09
Total	11	100.00

Table 2 shows that 8 teachers, or 72.73 per cent, stated that there are between 1 and 25 computers in working order at their institution, followed by 2 teachers, or 18.18 per cent, who stated that there are between 26 and 50 computers in use and

in good working order; and finally, 1 teacher, or 9.9 per cent, who stated that there are between 51 and 100 computers in use and in good working order.

The chi-squared test yielded a value of 7.812 ($p = 0.020$) with one degree of freedom; this leads us to reject the null hypothesis.

c. Student-to-PC ratio

Continuing our survey, we sought to determine the number of students who queue up at a computer during a practical session; the following question was asked: ‘How many students queue up at a computer during a practical session?’. The responses provided by our respondents are presented in the table below:

Table 3: Number of students who sit at a computer.

Number of students	Total	%
One student	4	33.33
Two students	4	33.33
Three students	1	8.33
Five students	1	8.33
More than 5 students	2	16.67
Total	12	100.00

Table 3 shows that 33.33 per cent, or 8 teachers, jointly stated that one or two students stand in front of a computer during a practical session; similarly, 8.33 per cent, or 2 teachers, also jointly confirmed that three or five students stand in front of a computer during a practical session, only 16.67 per cent – that is, just 2 out of 12 teachers – reported that more than 5 students gather around a computer during a practical session.

The chi-squared test yielded a value of 3.8333 ($p = 0.429$) with 4 degrees of freedom; this leads us to conclude that the difference is not significant.

3.2. Energy and Access to Digital Tools

Energy constraints and the availability of personal equipment determine the quality of the introductory training.

a. Use of Generators

Following the same line of reasoning, the following question was asked: ‘In the event of a power cut during a practical session, does the institution switch on the generator?’. The responses provided by our respondents are presented in the table below:

Table 4: Switching on a generator during a power cut.

Switching on a generator	Number of respondents	%
Never	5	41.67
Sometimes	5	41.67
Always	2	16.67
Total	12	100.00

Table 4 shows that 41.67 per cent, or 10 teachers, stated either ‘never’ or ‘sometimes’ that a generator is not switched on during a practical session and that it is sometimes switched on; only 16.67 per cent, or just 2 out of 12 teachers, reported that the generator is always switched on in the event of a power cut during a practical session.

The chi-squared test yielded a value of 1.5 ($p = 0.472$) with two degrees of freedom; this leads us to conclude that the difference is not significant.

b. Personal Computer

Next, the aim was to find out whether students have their own personal computer. To do this, the following question was asked: ‘Do you have a personal computer?’. The responses provided by our respondents are presented in the following table:

Table 5: Ownership of a personal computer per student.

Ownership of a personal computer	Number of students	%
No	136	26.46
Yes	378	73.54
Total	514	100.00

The results in Table 5 show that 73.54 per cent of students – that is, 378 out of 514 students – own a personal computer.

The chi-squared test yielded a value of 113 ($p = 0.000$) with one degree of freedom; this leads us to reject the null hypothesis.

c. Smartphone ownership

Following the same line of reasoning, the aim was to find out whether students own a smartphone. To this end, the following question was asked: ‘Do you have a smartphone?’. The responses provided by our respondents are presented in the following table:

Table 6: Smartphone ownership per student.

Smartphone ownership	Figures	%
No	90	17.51
Yes	424	82.49
Total	514	100.00

The results in Table 6 indicate that, whilst 17.51 per cent of students – that is, 90 out of 514 students – do not own a smartphone, 82.49 per cent – that is, 424 out of 514 students – do own a smartphone.

The chi-squared test yielded a value of 217.04 ($p = 0.000$) with one degree of freedom; this leads us to reject the null hypothesis.

3.3. Internet Connectivity: An Educational Divide

The lack of institutional connectivity isolates users from global resources.

a. Internet connection

In order to determine whether an internet connection exists within an institution, the following question was put to teachers: ‘Does your institution have an internet connection?’. The responses provided by our respondents are presented in the table below:

Table 7: Availability of an internet connection.

Internet connection	Number of staff	%
No	9	75.00
Yes	3	25.00
Total	12	100.00

The results in Table 7 show that a large majority – 9 out of 12 teachers, or 75 per cent – stated that there is no internet connection within their institutions.

The chi-squared test yielded a value of 3 ($p = 0.083$) with one degree of freedom; this leads us to conclude that the difference is not significant.

Similarly, the same question was put to the students: ‘Does your institution have an internet connection?’. The responses provided by our respondents are presented in the table below:

Table 8: Availability of an internet connection/Student.

Internet connection within the institution	Number of students	%
No	502	97.67
Yes	12	2.33
Total	514	100.00

The results in Table 8 show that a large majority – 502 out of 514 students, or 97.67 per cent – stated that there is no internet connection within their institutions.

The chi-squared test yielded a value of 467 ($p = 0.000$) with one degree of freedom; this leads us to reject the null hypothesis.

b. Users’ Access to the Internet

Subsequently, the aim was to determine whether, where an internet connection exists within an institution, teaching staff have access to it. The following question was asked: ‘If so (see the previous question), do you have access to this connection?’. The responses provided by our respondents are presented in the table below:

Table 9: Access to the institution’s internet connection.

Access to the institution’s internet connection	Number of staff	%
Never	9	75.00
Sometimes	3	25.00
Always	0	0.00
Total	12	100.00

The results in Table 9 show that, although 25 per cent of teachers – that is, 3 out of 12 – stated that they sometimes had access to their institutions’ internet connection, a large majority of 75 per cent of teachers – that is, 9 out of 12 – reported that they never had access to their institutions’ internet connection.

The chi-squared test yielded a value of 10.5 ($p = 0.005$) with two degrees of freedom; this leads us to reject the null hypothesis.

c. External Access to the Internet

In order to identify which teachers have access to the internet outside their institutions, the following question was asked: ‘Do you have access to the internet outside your institution (at home)?’. The responses provided by our respondents are presented in the table below:

Table 10: Access to the internet outside the institution.

Access to the internet outside the institution	Number of respondents	%
Sometimes	2	16.67
Often	3	25.00
Always	7	58.33
Total	12	100.00

The results in Table 10 show that 58.33 per cent of teachers – that is, 7 out of 12 – always have access to the internet outside their institution, followed by 25 per cent of teachers – that is, 3 out of 12 – who often have access to the internet outside their institutions, and finally 16.67 per cent of teachers – that is, 2 out of 12 – who stated that they sometimes have access to the internet outside their institutions.

The chi-squared test yielded a value of 3.5 ($p = 0.173$) with 2 degrees of freedom; this suggests that the difference is not statistically significant.

In the same context, the same question was put to the students: ‘Do you have access to the internet outside your institution (at home)?’. The responses provided by our respondents are presented in the table below:

Table 11: Access to the internet outside the institution/Students.

Internet outside the institution	Number of students	%
Never	91	17.70
Sometimes	125	24.32
Often	81	15.76
Always	217	42.22
Total	514	100.00

The results in Table 11 show that 42.22 per cent of students – that is, 217 out of 514 – always have access to the internet outside their institution, followed by 24.32 per cent of students – that is, 125 out of 514 – who sometimes have access to the internet outside their institution, then 17.70 per cent of students – 91 out of 514 – who stated that they never have access to the internet outside their institutions; and finally, 15.72 per cent – 81 out of 514 – who confirmed that they often have access to the internet outside their institutions.

The chi-squared test yielded a value of 89.549 ($p = 0.000$) with 3 degrees of freedom; this leads us to reject the null hypothesis.

4. Discussion

Analysis of material shortages and pedagogical adaptation

The advent of the Internet has transformed teaching towards digital self-learning via online platforms such as **MOOCs** or **Moodle** (Kitumu, 2009). However, in Lubumbashi, access to the Internet remains a ‘major problem’. For a discipline with an ‘evolving structure’, the lack of a permanent connection is a fatal flaw: it prevents software libraries from being updated and interaction with the global community, rendering the content taught rapidly obsolete.

Impact on IDE learning: The ‘Pen-and-Paper’ syndrome

The inadequate IT infrastructure and the lack of software teaching materials prevent the effective ‘implementation’ of the Integrated Development Environment (IDE). In the absence of regular practice, the introduction to the subject is described as ‘poor’ (Mandela, 2023, p. 10). Teaching is reverting to a logical approach centred on ‘pen-and-paper’ algorithmics (Nijimbere, 2015). This disconnect between theory and the practical use of IDEs leads to students becoming quickly discouraged, as they are unable to realise their dreams of programming.

Ownership and Institutional Resistance

Our findings corroborate the work of **Galekwa (2010)**, highlighting that teachers often have to engage in ‘self-appropriation’ to compensate for the limited resources made available by institutions. Similarly, the resistance factors identified by **Ouédraogo (2011)** — material constraints and a lack of technical support — manifest themselves here as systemic barriers to pedagogical innovation in the DRC.

Conclusion and recommendations

Summary

The study demonstrates that the teaching environment in Lubumbashi is not suitable for an effective introduction to programming. The lack of computer labs, overcrowding at the computers and the absence of internet connectivity create a precarious learning environment that marginalises students and teachers.

Recommendations

- **To Institutions:** It is imperative to organise teaching within an appropriate setting, equipped with functional laboratories and teaching materials (up-to-date software and IDEs).
- **To the Government:** Update the computer science curriculum by incorporating technical and evolving aspects, whilst providing technical support to institutions to bridge the digital divide.
- **To Teachers:** Adopt active teaching methods and suitable development environments to encourage self-directed learning.

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